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(54) **SYSTEMS AND METHODS FOR ENCODING AND SHARING CONTENT BETWEEN DEVICES**

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**H04N 21/2343** (2011.01)

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(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,103,906 B1 9/2006 Katz et al.  
8,148,622 B2 4/2012 Rothkopf et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 107111477 A 8/2017  
CN 106254900 B 9/2019

(Continued)

OTHER PUBLICATIONS

Toldo, Marco; Magli, Enrico. A resilient and low-delay P2P streaming system based on network coding with random multicast trees. 2010 IEEE International Workshop on Multimedia Signal Processing. <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5662054> (Year: 2010).\*

(Continued)

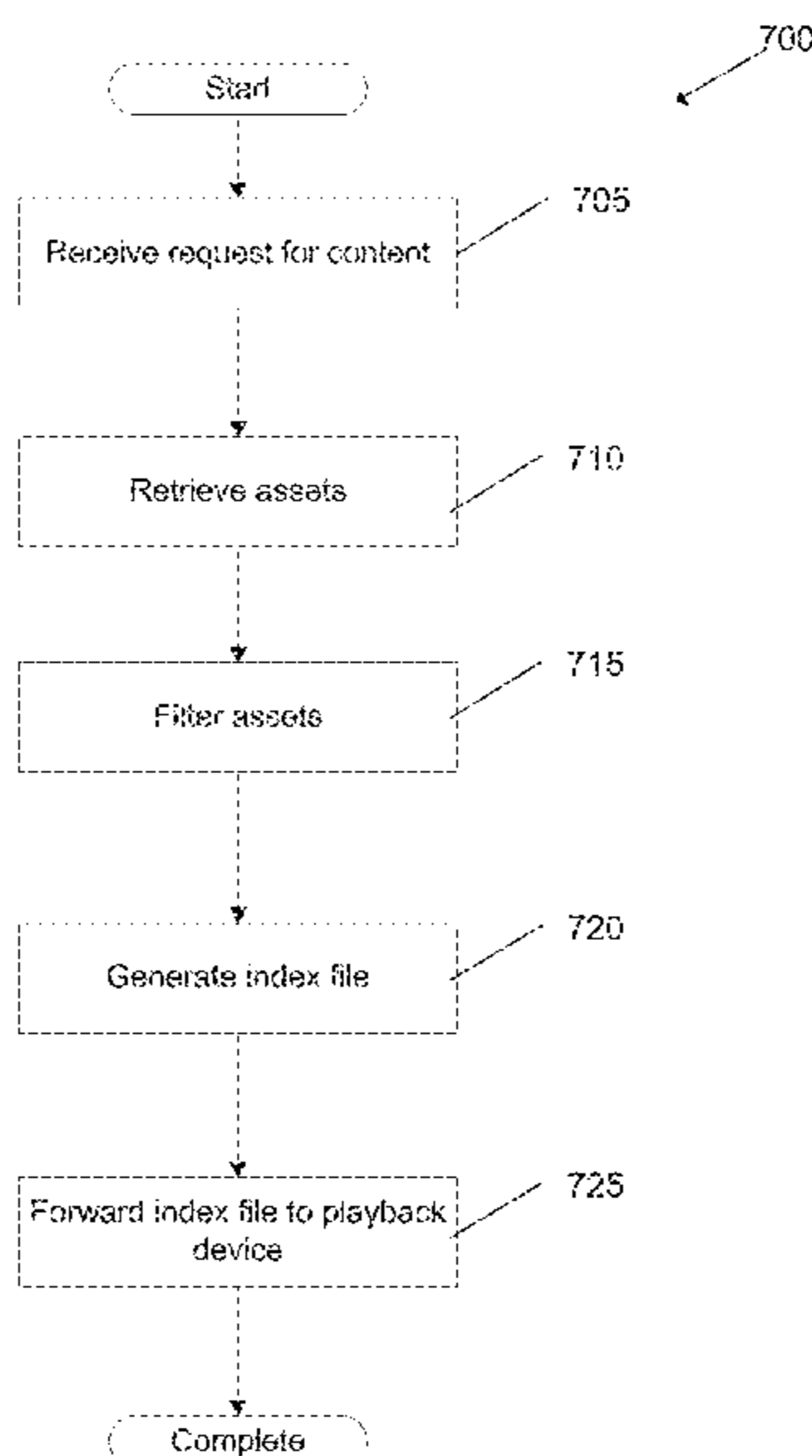
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(57) **ABSTRACT**

Systems and methods for sharing content between devices are disclosed. To request a shared piece of media content, a playback device generates and sends a request to content server. The playback device includes information in the request that indicates the playback capabilities of the device. The content server receives the request and determines the playback capabilities of the playback device from the information in the request. The content server then determines the assets that may be used by the playback device to obtain the media content and generates a top level index file for the playback device that includes information about the determined assets. The top level index file is then sent to the playback device that may then use the top level index file to obtain the media content using the indicated assets.

**20 Claims, 8 Drawing Sheets**



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- (52) **U.S. Cl.**  
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(56) **References Cited**

U.S. PATENT DOCUMENTS

8,407,753	B2	3/2013	Kuo
8,423,889	B1	4/2013	Zagorie et al.
8,638,935	B2	1/2014	Fasoli et al.
8,677,428	B2	3/2014	Lewis et al.
8,725,125	B2	5/2014	Klappert et al.
8,819,577	B2	8/2014	Fino
8,856,847	B2	10/2014	Soroushian
8,909,682	B2	12/2014	Heller et al.
8,918,535	B2	12/2014	Ma et al.
9,037,683	B1	5/2015	Yoden
9,161,005	B2	10/2015	Rose et al.
9,380,099	B2 *	6/2016	Amidei ..... H04L 65/607
9,507,776	B2 *	11/2016	Bartholomew ..... G06F 16/40
9,661,044	B2	5/2017	Arana et al.
10,154,075	B2	11/2018	Braness et al.
10,225,298	B2	3/2019	Cen et al.
2005/0005025	A1	1/2005	Harville et al.
2007/0074254	A1 *	3/2007	Sloo ..... H04N 5/44543 725/52
2008/0301734	A1 *	12/2008	Goldeen ..... H04N 5/44543 725/44
2009/0132599	A1 *	5/2009	Soroushian ..... G11B 27/10
2009/0187957	A1 *	7/2009	Avkarogullari ..... H04N 5/775 725/109
2011/0096828	A1 *	4/2011	Chen ..... H04N 21/23106 375/240.02
2011/0231569	A1 *	9/2011	Luby ..... H04L 65/607 709/234
2012/0170642	A1 *	7/2012	Braness ..... G11B 27/005 375/240.01
2012/0254456	A1 *	10/2012	Visharam ..... H04N 21/2343 709/231
2013/0179199	A1 *	7/2013	Ziskind ..... G06F 21/10 705/5
2014/0223303	A1 *	8/2014	Cox ..... H04L 65/60 715/716
2015/0019866	A1	1/2015	Braness et al.
2016/0197971	A1	7/2016	Cen et al.
2019/0173932	A1	6/2019	Braness et al.

FOREIGN PATENT DOCUMENTS

EP	3243130	B1	8/2019
HK	1246429	A	9/2018
JP	2001204001	A	7/2001
JP	2008507160	A	3/2008
JP	2018505594	A	2/2018
JP	6522723	B2	5/2019
JP	2019134487	A	8/2019
KR	101903352	B1	10/2018
KR	101955363	B1	3/2019
KR	102012682	B1	8/2019
WO	2005111835	A2	11/2005
WO	2005111835	A3	3/2009
WO	2013032517	A1	3/2013

OTHER PUBLICATIONS

Shah, Wahidah Md.; Race, Nicholas J.P. Localising Peers in P2P Live Streaming Systems Within Resource-Constrained Networks. 2012 International Conference on Computer&Information Science (ICIS). <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6297115> (Year: 2012).\*

Extended European Search Report for European Application No. 19185179.9, Search completed Jul. 26, 2019, dated Aug. 5, 2019, 10 pgs.

Caglar et al., "MUVIS: A Content-Based Multimedia Indexing and Retrieval Framework", 2003 Proceedings of Seventh International Symposium on Signal Processing and Its Applications, Jul. 4, 2003, vol. 1, pp. 1-8, DOI: 10.1109/ISSPA.2003.1224626.

Chen et al., "A Spatio-Temporal Semantic Model for Multimedia Database Systems and Multimedia Information Systems", IEEE Transactions on Knowledge and Data Engineering, Jul./Aug. 2011, vol. 13, No. 4, pp. 607-622, DOI: 10.1109/69.940735.

Chen et al., "Audio-on-Demand over Wireless Sensor Networks", 2012 IEEE 20th International Workshop on Quality of Service, Jun. 4-5, 2012, pp. 1-9, DOI: 10.1109/IWQoS.2012.6245981.

Ding et al., "Multisource Video On-Demand Streaming in Wireless Mesh Networks", IEEE/ACM Transactions on Networking, Dec. 2012, Date of Publication: Mar. 7, 2012, vol. 20, No. 6, pp. 1800-1813, DOI: 10.1109/TNET.2012.2188642.

Guo et al., "A Multi-server Video Monitor System Based on Stream-Media Communication Technology", 2008 2nd International Symposium on Systems and Control in Aerospace and Astronautics, Dec. 10-12, 2008, Shenzhen, China, pp. 1-4, DOI: 10.1109/ISSCAA.2008.4776278.

Miras, "On Quality Aware Adaptation of Internet Video", University of London, PhD dissertation, May 2004, 181 pgs.

Nelson, "Smooth Streaming Deployment Guide", Microsoft Expression Encoder, Aug. 2010, 66 pgs.

Padiadpu, Rashmi, "Towards Mobile Learning: A SCORM Player for the Google Android Platform", Master Thesis, Hamburg University of Applied Sciences, 2008, 66 pgs.

Paul et al., "VtonDemand: A Framework for Indexing, Searching, and On-Demand Playback of RTP-Based Multimedia Conferences", 1999 IEEE Third Workshop on Multimedia Signal Processing (Cat. No. 99th8451), Sep. 13-15, 1999, pp. 59-64, DOI: 10.1109/MMSP.1999.793798.

\* cited by examiner

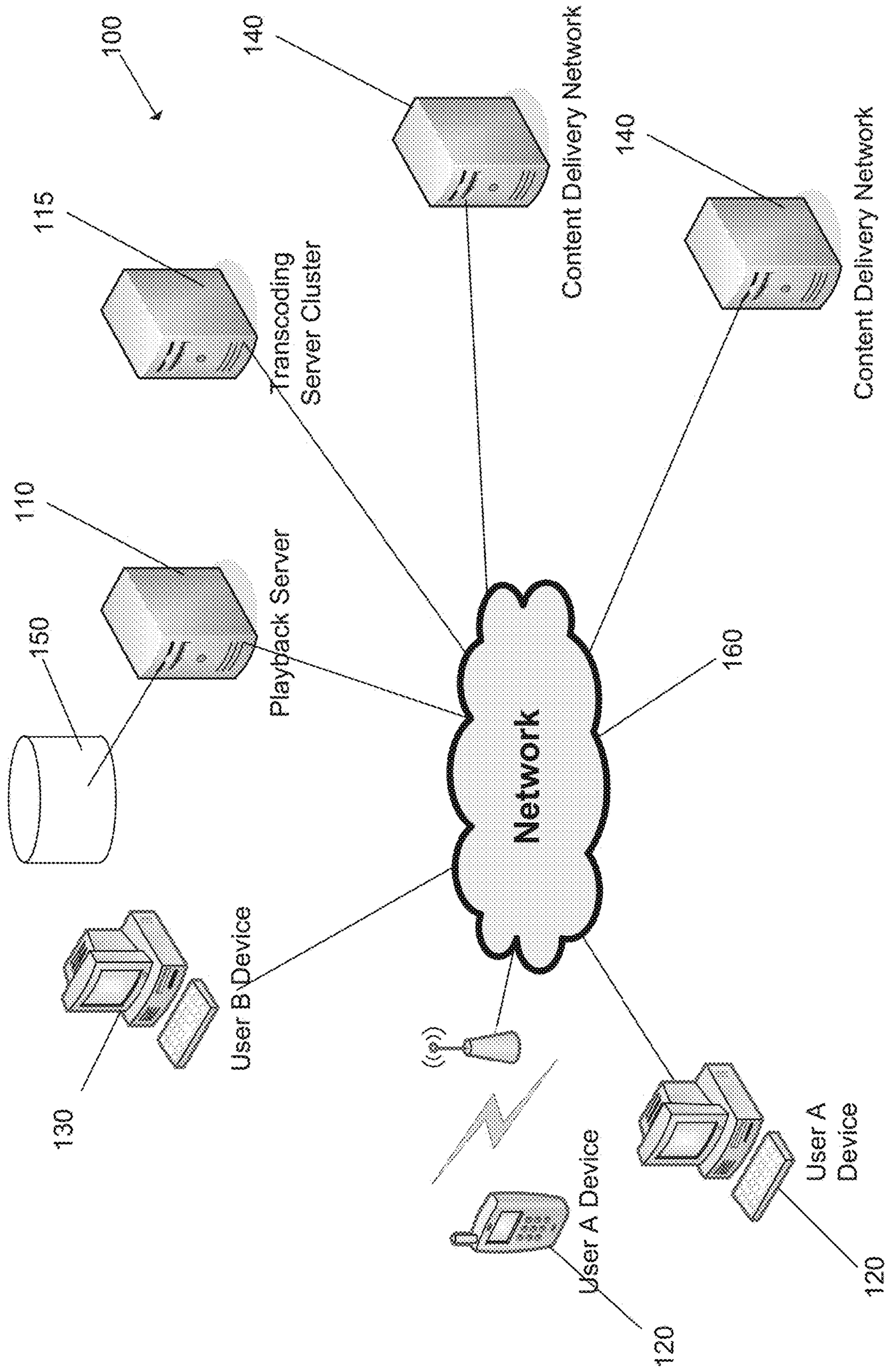


FIG. 1

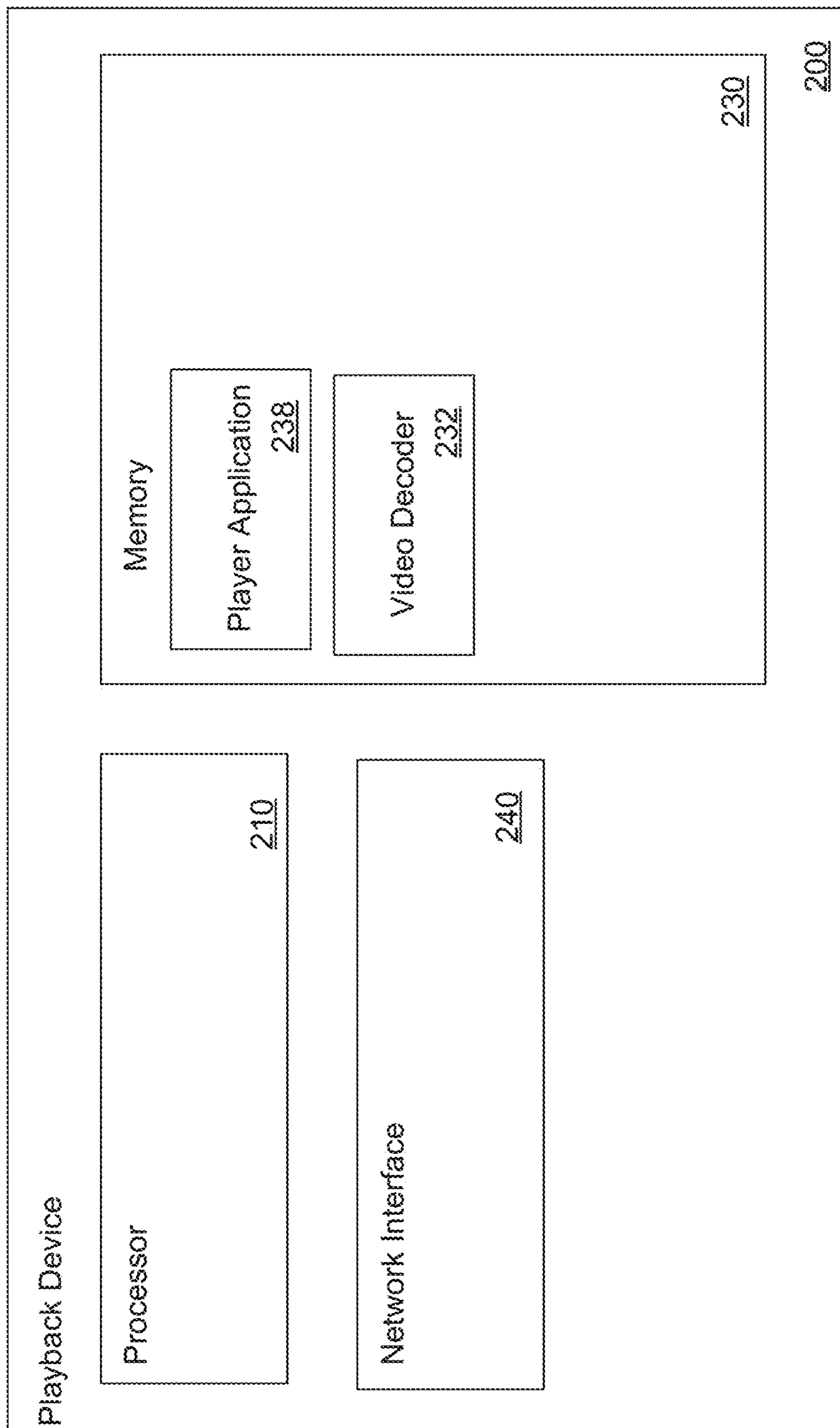


FIG. 2

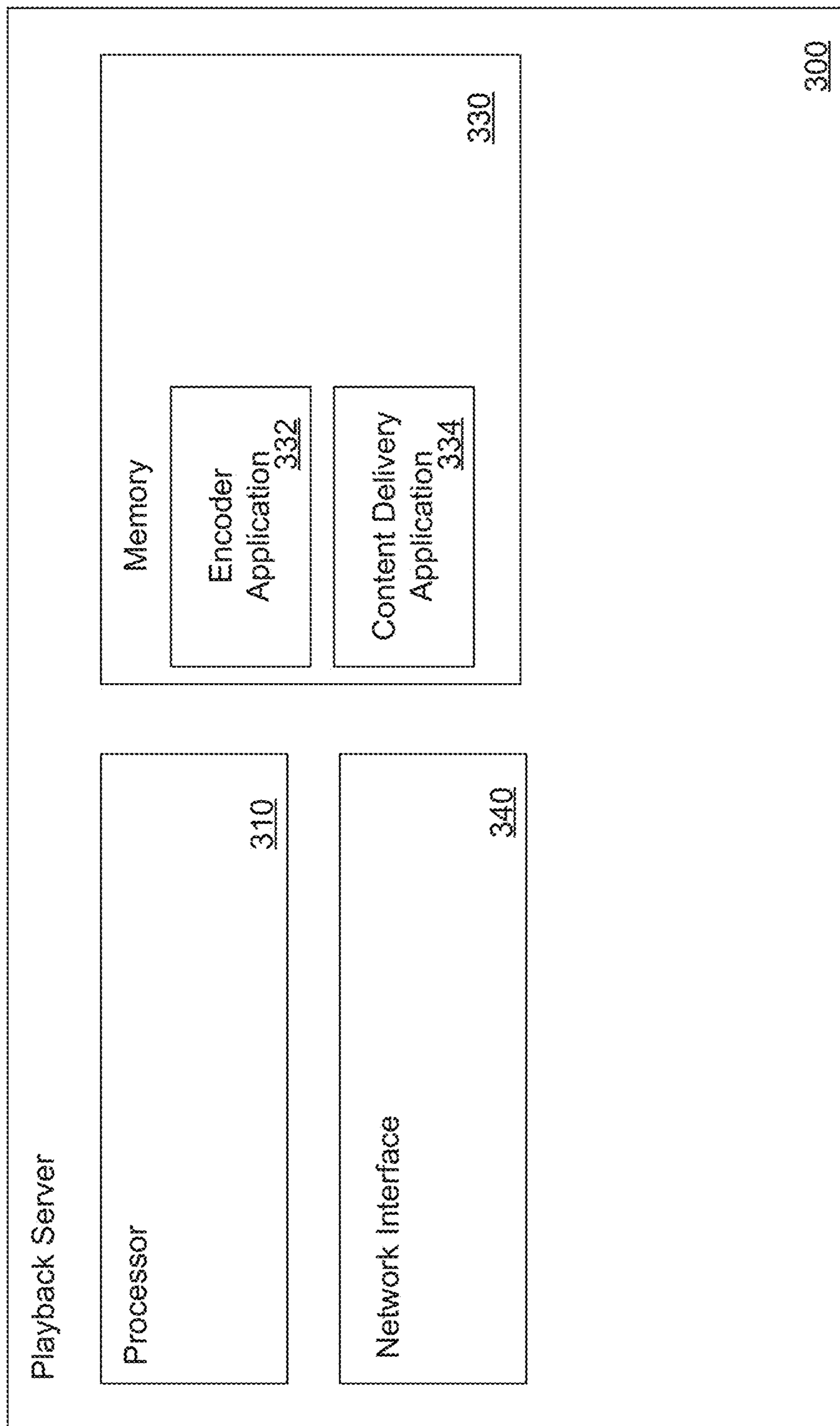


FIG. 3

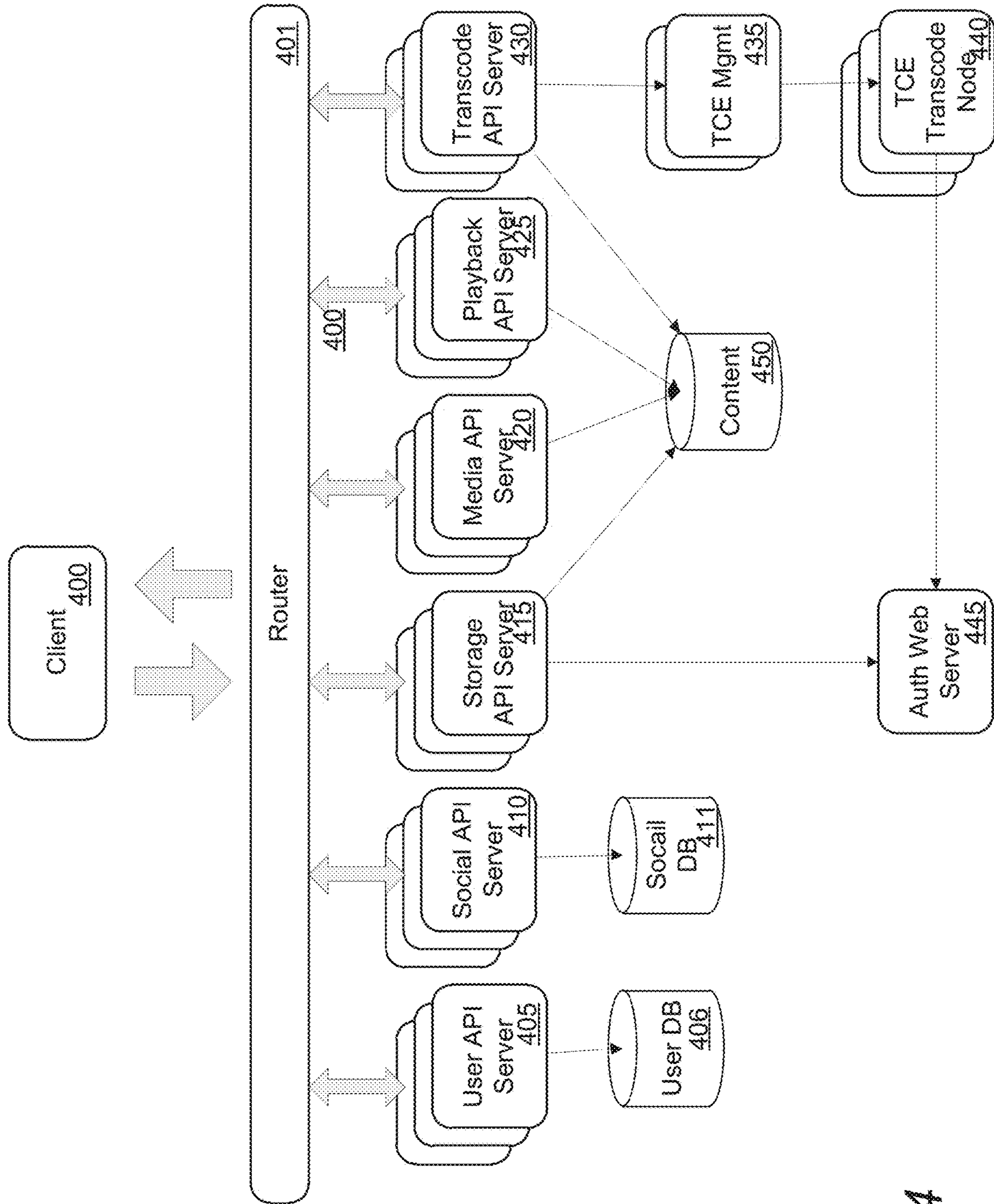


FIG. 4

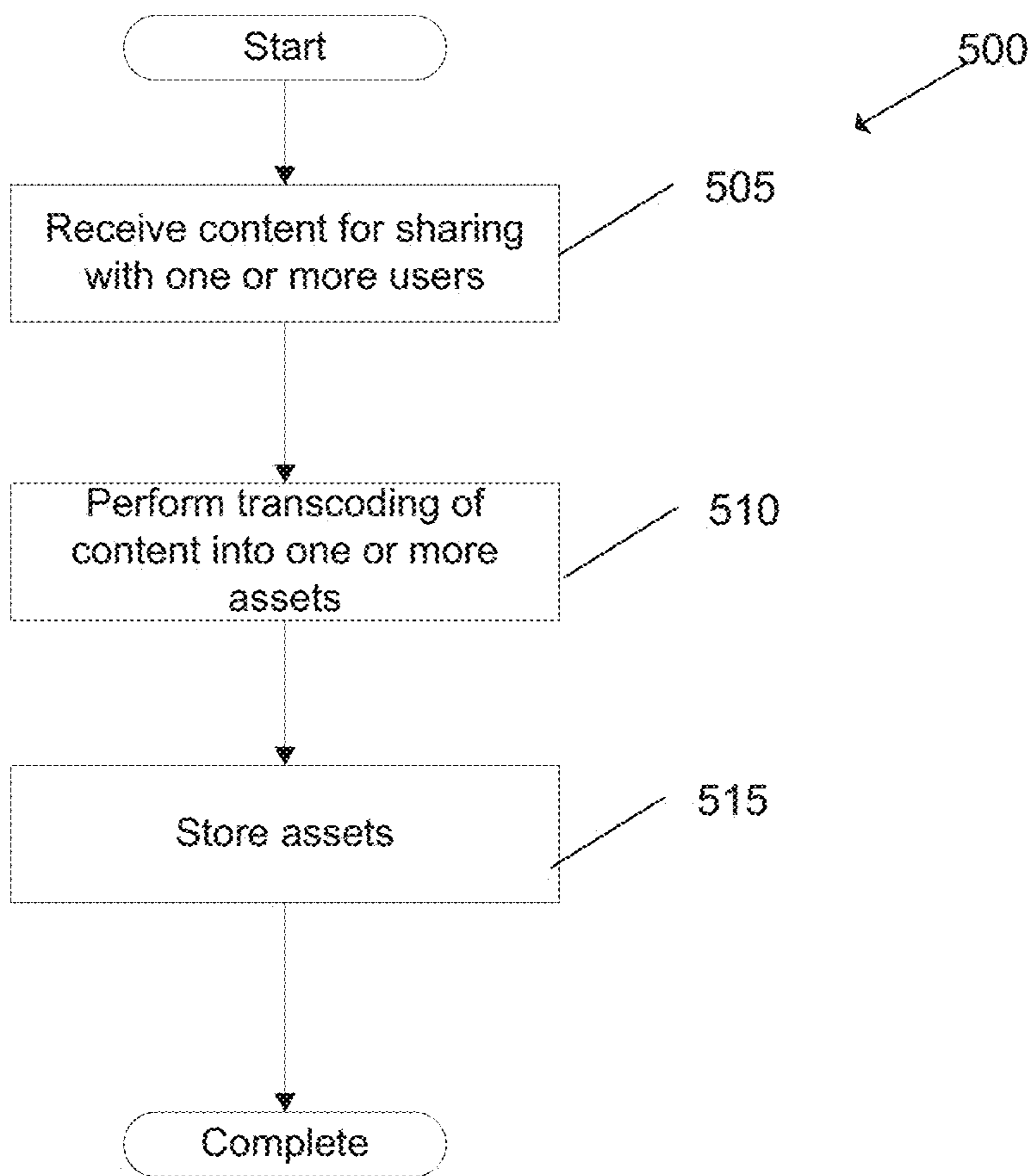


FIG. 5

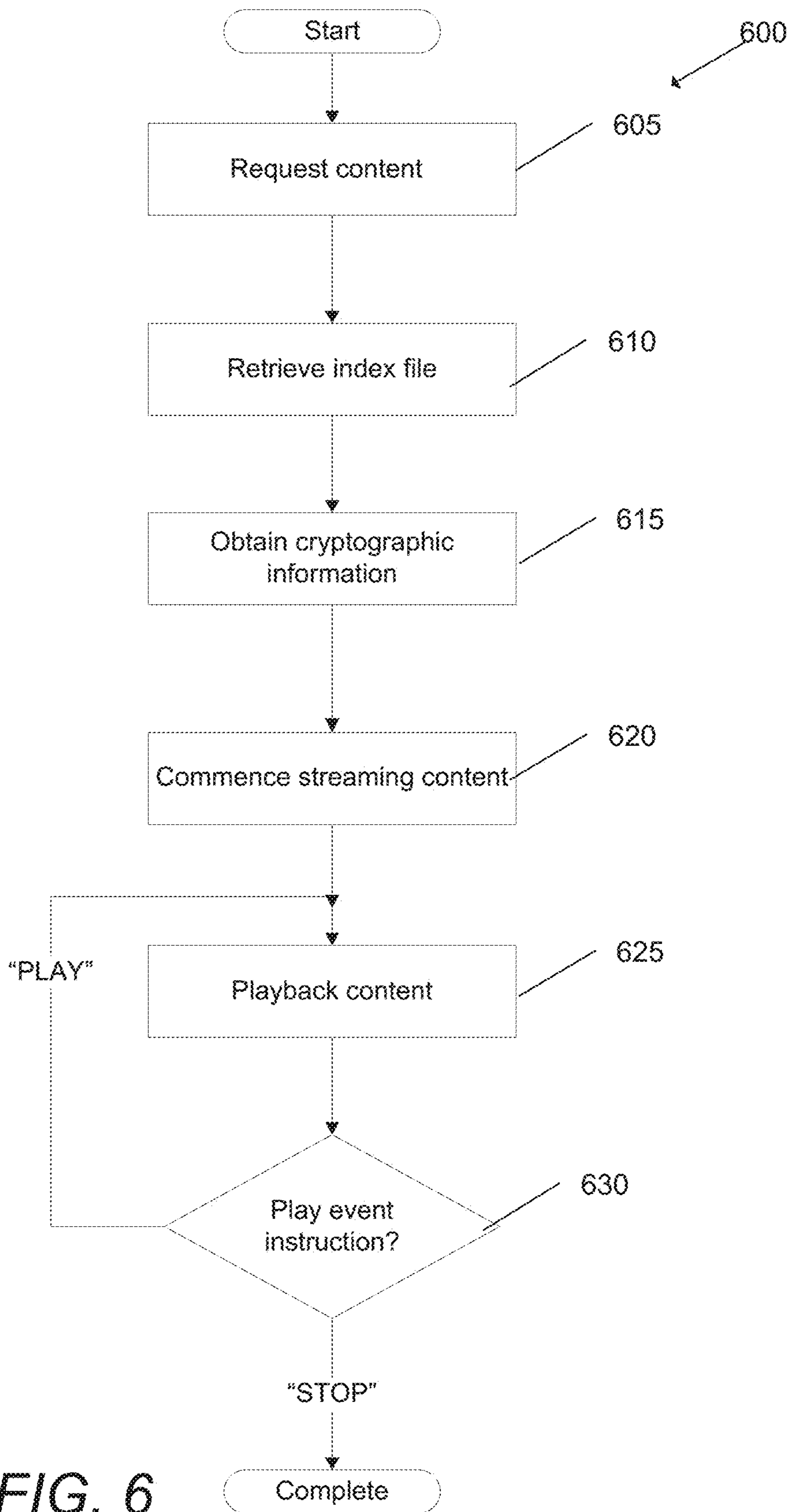
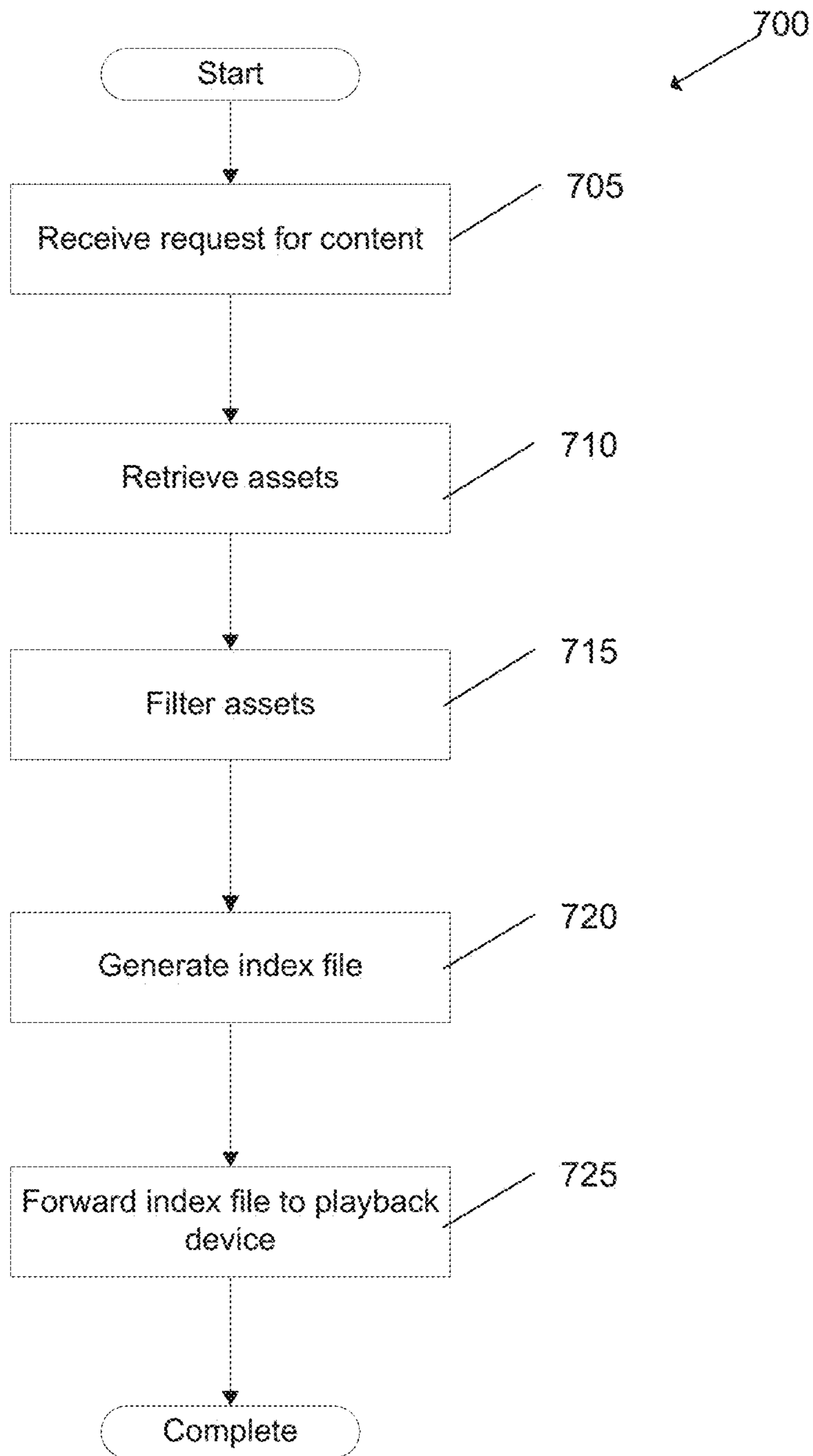


FIG. 6





**FIG. 7**

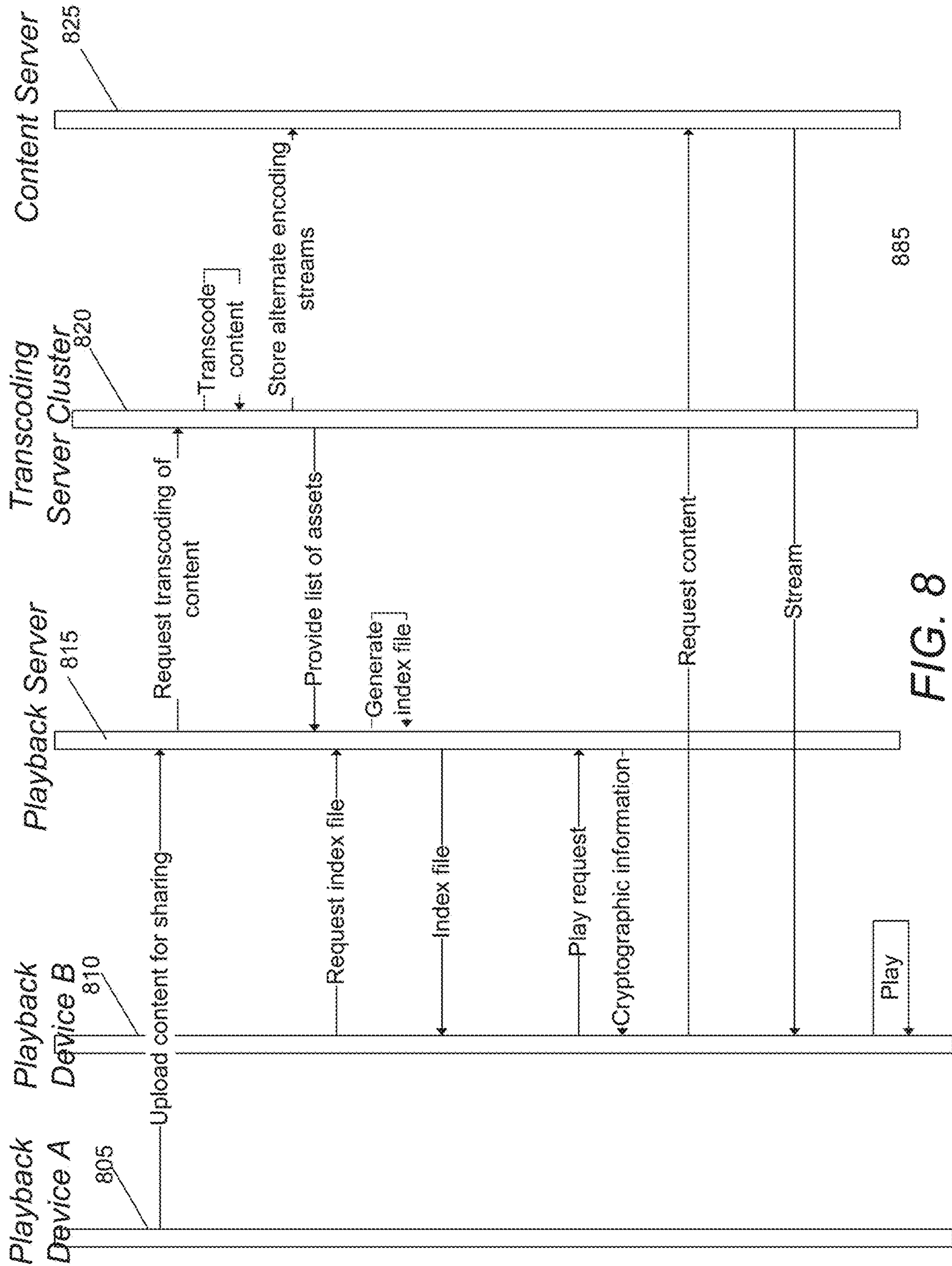


FIG. 8

# SYSTEMS AND METHODS FOR ENCODING AND SHARING CONTENT BETWEEN DEVICES

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 14/989,551 entitled "Systems and Methods for Encoding and Sharing Content between Devices" to Cen et al., filed Jan. 6, 2016, which claims priority to U.S. Provisional Application 62/100,299 entitled "Systems and Methods for Encoding and Sharing Content between Devices" to Cen et al., filed Jan. 6, 2015, the disclosures of which are incorporated herein by reference in their entireties.

## FIELD OF THE INVENTION

The present invention generally relates to sharing content with devices with different capabilities and more specifically to transcoding a content file into one or more different encodings and generating, based on a playback device's capabilities, an index file of the alternate encodings for use in playback of the encoded content on the playback device.

## BACKGROUND

Advances in technology have provided users of computing devices with the ability to instantaneously and seamlessly share media content (i.e., photos, videos, documents, among other file types) between different devices of a user and/or different users (e.g., friends and family) with many different technology companies providing various platforms for engaging in such activities. For example, social media has permitted the instantaneous sharing of photos and videos across mobile devices, desktop computers, tablets, and many other types of devices with different video playback capabilities. Other cloud based storage platforms have allowed users to share content by providing, for example, a URL to a location of content to other users with whom they would like to share content. Different services may use different technology implementations to deliver content to users. Technology providers often consider many different factors when implementing a particular content delivery mechanism including, but not limited to, the storage required to store content on a platform, the processing necessary to stream content to different devices, network considerations including bandwidth requirements, and the amount of latency experienced by mobile devices in viewing content. Furthermore, with the rapid progress in the quality of videos available, these considerations become ever more vital when implementing a particular technology standard.

In general, video content may be delivered to user device by streaming and/or downloading. The term streaming media describes the playback of media on a playback device, where the media is stored on a server and continuously sent to the playback device over a network during playback. Typically, the playback device stores a sufficient quantity of media in a buffer at any given time during playback to prevent disruption of playback due to the playback device completing playback of all the buffered media prior to receipt of the next portion of media. Adaptive bit rate streaming or adaptive streaming involves detecting the present streaming conditions (e.g. the playback device's network bandwidth and video decoding capacity) in real time and adjusting the quality of the streamed media accordingly. Typically, the source media is encoded as separate streams

having different maximum bitrates and the playback device or client switches between streaming the different encodings depending on available resources. When a playback device commences adaptive bitrate streaming, the playback device typically starts by requesting portions of media from an initial set of streams. As the playback device downloads the requested media, the playback device can measure the available bandwidth. In the event that the available bandwidth increases or decreases, the playback device can switch to higher or lower bitrate streams.

Adaptive streaming solutions typically utilize Hypertext Transfer Protocol (HTTP), published by the Internet Engineering Task Force and the World Wide Web Consortium as RFC 2616, to stream media between a server and a playback device. HTTP is a stateless protocol that enables a playback device to request a byte range within a file. HTTP is described as stateless, because the server is not required to record information concerning the state of the playback device requesting information or the byte ranges requested by the playback device in order to respond to requests received from the playback device.

In adaptive streaming systems, the source media is typically stored on a media server as a top level index file pointing to a number of alternate streams that contain the actual video and audio data. Each stream is typically stored in one or more container files. Different adaptive streaming solutions typically utilize different index and media containers. The Synchronized Multimedia Integration Language (SMIL) developed by the World Wide Web Consortium is utilized to create indexes in several adaptive streaming solutions including IIS Smooth Streaming developed by Microsoft Corporation of Redmond, Wash., and Flash Dynamic Streaming developed by Adobe Systems Incorporated of San Jose, Calif. HTTP Adaptive Bitrate Streaming developed by Apple Computer Incorporated of Cupertino, Calif. implements index files using an extended M3U playlist file (.M3U8), which is a text file containing a list of URIs that typically identify a media container file. The most commonly used media container formats are the MP4 container format specified in MPEG-4 Part 14 (i.e. ISO/IEC 14496-14) and the MPEG transport stream (TS) container specified in MPEG-2 Part 1 (i.e. ISO/IEC Standard 13818-1). The MP4 container format is utilized in IIS Smooth Streaming and Flash Dynamic Streaming. The TS container is used in HTTP Adaptive Bitrate Streaming.

## SUMMARY OF THE INVENTION

Systems and method for encoding and sharing content between devices in accordance with some embodiments of the invention are disclosed. In accordance with some embodiments of the invention, media content is shared in the following manner. A content server receives shared media content from a first playback device. The content server obtains a transcoding of the shared media content that includes assets to provide the shared media content in a plurality of alternative streams. The content server then receives a request for the shared media content from a second playback device. The request includes device capability information of the second playback device. The content server generates a top level index file that includes information for assets that can be used to provide the shared media content to the second playback device based upon the device capability information for the second playback device and transmits the top level index file from the content server to the second playback back device.

In accordance with some embodiments, the top level index file is generated in the following manner. The content server retrieves the information about assets that provide the shared media content from a memory storing the assets. The capabilities of the second playback device are determined by the content server from the device capability information and the information about the assets is filtered by the content server based upon the determined capabilities of the second playback device and information for assets that meet criteria for the capabilities of the second playback device are included in the top level index file using the content server.

In accordance with many embodiments, the device capability information provided by the second playback device includes a product identifier for the second playback device and the determining of the capabilities of the second playback device is determined by the content server retrieving the capabilities of the second playback device from a memory that stores the capabilities of a playback device having the product identifier of the second playback device included in the device capability information. In a number of embodiments, the capabilities of the playback second device are included in the device capability information in the request and content server determines the capabilities of the second playback device by obtaining the capabilities from the device capabilities information in the request using the content server.

In accordance with some embodiments of the invention, the assets included in the top level index file are also based upon rules regulating the use of different assets for providing the shared media content that are stored in memory. In accordance with many of these embodiments, the rules regulating the use different assets include at least one rule selected from the rules consisting of: the type of playback device, the playback capabilities of the device, and location of the device, and a requested language.

In accordance with some embodiments, the assets included in the top level index file are also based upon at least one criteria selected from the group of criteria selected from the group consisting of user preferences, and requirements of the content owner.

In accordance with some embodiments, a playback device receives shared content in the following manner. The playback device generates a request for shared media content shared with the playback device by another playback device. The request includes device capability information of the playback device and a token associated with the shared media content that was received from the other playback device. The playback device transmits the request to a content server. In response to the request, the playback device receives a top level index file from the content server. The top level index file includes information for assets that can be used to obtain the particular media content to the device based upon the device capability information for the playback device. The playback device then obtains the media content in playback device using the information in the top index file.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a network diagram of a content delivery system including a playback server and a transcoding server in accordance with an embodiment of the invention.

FIG. 2 is a system diagram of a playback device in accordance with an embodiment of the invention.

FIG. 3 is a playback server configured to deliver content to a plurality of different devices in accordance with an embodiment of the invention.

FIG. 4 is an architecture diagram of a content transcoding and delivery system in accordance with an embodiment of the invention.

FIG. 5 conceptually illustrates a process for uploading and transcoding content for sharing with one or more different user devices.

FIG. 6 conceptually illustrates a process for playing back content using a top level index file generated in response to a request from a playback device in accordance with an embodiment of the invention.

FIG. 7 conceptually illustrates a process for generating a top level index file using information concerning assets associated with specific pieces of content maintained by a playback server in accordance with an embodiment of the invention.

FIG. 8 conceptually illustrates a communication diagram providing a series of communications between different devices and various server systems for uploading and sharing content to the user devices in accordance with an embodiment of the invention.

#### DETAILED DESCRIPTION

Turning now to the drawings, systems and methods for transcoding an encoded content file into one or more different encodings and generating, based on a device's capabilities, a top level index file of the different encodings for use in playback of the encoded content in accordance with embodiments of the invention are illustrated. In several embodiments, an application on a computing device such as (but not limited to) a mobile phone and/or tablet computer is used to share video content captured and encoded by the computing device. In a number of embodiments, the sharing process involves uploading the encoded video file to a content delivery system that transcodes the encoded content into different encodings for adaptive bitrate streaming to other devices. In many embodiments, the content delivery system controls the distribution of the different encodings to provide secure sharing of the content. The different encodings may be based on the capabilities of the different devices to which a content file will be shared. For example, video content captured in "4K" or "Ultra HD" resolution and that is to be shared with several different devices with different video decoders and playback capabilities may be transcoded using an HEVC codec for the 4K stream and an H.264 codec for an HD (i.e., 1080p) stream. Similarly, the content delivery system can generate different top level index files for different devices to which the content file will be shared based on the particular capabilities of each of the devices. In particular, for a device capable of playing back the 4K encoded stream, the top level index file provided to the device may include information about both the available HEVC and H.264 encodings of the content file. By contrast, for a device that is not capable of playing back the 4K HEVC stream, the top level index file provided to that device may only include information for obtaining the HD H.264 stream. In some embodiments, a content file may be transcoded into several different encoding standards (e.g., H.265/MPEG-H HEVC, H.264/MPEG-4 AVC, H.263/MPEG-4 Part 2, H.262/MPEG-2, Google™ (On2) codecs, Microsoft™ codecs) in order to allow for the content to be shared with devices with different playback capabilities (e.g., encoding/decoding capabilities, resolution, network bandwidth) and/or various other requirements. The specific codecs that are utilized are typically dependent upon the requirements of a specific application.

A top level index is a file that describes the location and content of container files containing different encodings (e.g., H.265/MPEG-H HEVC, H.264/MPEG-4) of media (e.g. audio, video, metadata, and subtitles) that can be utilized by the playback device to stream and playback content. In adaptive bitrate streaming systems, the top level index file typically references the alternative encodings of a content file that the playback device can switch between. In many embodiments, a top level index file is generated in response to a request from a playback device for a content file. For example, a playback device A may share a video file with a playback device B and the top level index file may be generated upon the playback device B requesting playback of the content.

In several embodiments, the process of generating the top level index file involves determining all of the different encodings or container files containing streams associated with a specific piece of content and then filtering the assets based upon one or more predetermined criterion and/or capabilities of a device. In a number of embodiments, the assets are filtered based upon predetermined criteria including (but not limited to) business rules defined by the content owner, device capabilities of the user's with whom the content will be shared, and/or information associated with a user account. In many embodiments, the top level video file that is generated is a SMIL file. In certain embodiments, the top level index file is an MPD file used within the MPEG-DASH standard. In other embodiments, any of a variety of file formats can be utilized to generate top level index files in accordance with embodiments of the invention.

In several embodiments, a playback server automatically generates one or more top level index files, each index file for a particular device with whom a content file is to be shared, in response to a request from a playback device to share the content file with the plurality of different user devices and the playback server can also provide the different devices with cryptographic information enabling playback of protected streams of content. Playback devices, playback servers and processes for transcoding content into different encoding assets for sharing with different users and/or devices and generating top level index files in response to requests from playback devices in accordance with embodiments of the invention are discussed further below.

#### Content Delivery System Architecture

Content delivery systems in accordance with many embodiments of the invention include a playback server that transcodes a content file that is to be shared to different devices into a plurality of different encoding streams. When devices request playback of the content, the content delivery system can automatically generate top level index files in response to the requests and based upon the different capabilities of the playback devices. A content delivery system in accordance with an embodiment of the invention is illustrated in FIG. 1. The content delivery system 100 includes a number of playback devices 120-130, including user A devices 120 and user B device 130, configured to upload content for sharing with other user devices and/or request playback (e.g., streaming and/or downloading) of content from remote servers within content delivery networks (CDNs) 140 via a network 160 such as the Internet. In order to stream content for sharing, a playback device obtains a top level index file that is automatically generated by the playback server 180 for the particular device using a database 150 of available assets (i.e. container files containing streams of content associated with specific titles) and a set

of predetermined filters or criteria based on the capabilities of the particular playback device.

In many embodiments, a playback device may perform adaptive bitrate streaming by selecting content from different alternative streams described in the top level index file based upon identifying information provided by the playback device. Systems and methods for adaptive bitrate streaming using automatically generated top level index files are described in U.S. patent application Ser. No. 13/341,789 to Shaifer et al., entitled "Systems and Methods for Automatically Generating Top Level Index Files", filed Dec. 30, 2011 and issued as U.S. Pat. No. 8,787,570. The disclosure of U.S. Pat. No. 8,787,570 is incorporated by reference herein in its entirety.

The playback server 110 may obtain a content file from a user device 120-130 and use the transcoding server cluster 115 to transcode the encoded content file into one or more alternative streams that use different encoding standards. The transcoded content files may be stored in the asset storage 150 database of available assets (i.e. container files containing different streams of encoded content associated with specific titles). As described above, alternative streams (or alternative encoded assets) are streams that encode the same media content in different ways. In many instances, alternative streams encode media content (such as but not limited to video) using different encoding standards (e.g., HEVC or H.264) and/or encode the content at different maximum bitrates. In a number of embodiments, the alternative streams are encoded with different resolutions and/or at different frame rates. In many embodiments, the top level index file generated by the playback server 180 for a particular playback device describes at least the maximum bitrates of each of the alternative streams. The playback device can select one or more streams for conventional streaming or can switch between alternative streams to perform adaptive bitrate streaming.

In several embodiments, when one playback device 120-130 shares a piece of content with another playback device, the playback device 120-130 receives the shared content by way of a token that can be provided to the playback server 110 to stream and/or download the content. When a playback device transmits the token to server 110, the playback device 120-130 can append information describing playback capabilities of the playback device 120-130 that the playback server 110 can utilize to automatically generate a top level index file for the playback device 120-130 using information stored in database 150. The playback server 110 is typically a conventional server system configured using a playback management application and in such a way that the playback server can access the database 150. In a number of embodiments, playback devices 120-130 provide information concerning their playback capabilities to the playback server 110 and the server 110 automatically generates top level index files by filtering assets associated with a shared piece of content based upon device capabilities. Such capabilities include, but are not limited to, playback capabilities, encoding/decoding codec, display aspect ratio, and/or anticipated maximum network connection data rate. In a number of embodiments, the capabilities of a specific playback device 120-130 are communicated to the playback server 110 in the form of a product identifier or product ID. The playback server 110 can maintain a database of product IDs and associated device capabilities, and can utilize the product IDs provided by playback devices to retrieve the associated device capabilities and apply filters to lists of available assets when generating a top level index file. Systems and methods for assigning product IDs and associating them

with information concerning the capabilities of the devices to which the product IDs are assigned are described in U.S. Provisional Publication No. 2013/0006869 to Grab et al., entitled “Method to Identify Consumer Electronics Products”, filed Mar. 31, 2012. The relevant disclosure from U.S. Provisional Publication No. 2013/0006869 related to using product identifiers to identify the playback capabilities of specific devices is incorporated by reference herein in its entirety. Other filters that can be applied by playback servers in accordance with embodiments of the invention include (but are not limited to) filters based upon the location of the playback device (i.e. country/region), and languages associated with a specific user. Various filters that can be applied to generate a top level index file in accordance with embodiments of the invention are discussed further below.

In several embodiments, the shared content is further secured through the use of encryption and digital rights management (DRM) technology. When the playback server **110** receives a request from a playback device **120-130** to playback encrypted content, the playback server retrieves cryptographic information required to playback protected streams of content. The playback device can then request portions of container files containing streams of content from one or more servers within a content delivery network **140** and can use the cryptographic information to access protected content. Systems and methods for the digital rights management of protected streams used in adaptive bitrate streaming are described in U.S. Pat. No. 8,909,922 to Kiefer et al., entitled “Systems and Methods for Playing Back Alternative Streams of Protected Content Protected Using Common Cryptographic Information”. The disclosure of U.S. Pat. No. 8,909,922 is incorporated by reference herein in its entirety.

Although a specific content delivery system is illustrated in FIG. 1, playback servers that transcode an encoded content file into alternative streams and automatically generate top level index files based on device capabilities can be incorporated into any of a variety of content delivery system architectures in accordance with some embodiments of the invention. Playback devices that can be utilized to playback content in accordance with some embodiments of the invention are discussed further below.

#### Playback Devices

Playback devices that can be utilized to securely share content in accordance with embodiments of the invention can include personal computers, CE players, and mobile phones. In many embodiments, playback devices can include consumer electronics devices such as DVD players, Blu-ray players, televisions, set top boxes, video game consoles, tablets, and other devices that are capable of connecting to a server and playing back encoded media. The basic architecture of a playback device in accordance with an embodiment of the invention is illustrated in FIG. 2. The playback device **200** includes a processor **210** in communication with memory **230** and a network interface **240**. In the illustrated embodiment, the memory includes a player application **238** that configures the processor and the playback device to request content from a playback server. In some embodiments, the player application **238** may request the content be streamed and/or downloaded to the playback device **200**. The memory **230** also includes a video decoder **232** that can decode encoded video for playback. Different devices may include software and/or hardware with different encoders/decoders (i.e., “codecs”) for decoding content. For example, for a playback device capable of playing back 4K video, the decoder may be an HEVC decoder. For a playback device capable of playing back HD (i.e., 1080p) video, the

decoder may be an H.264 decoder. In many embodiments, the playback device may include multiple decoders to support different media formats.

During operation, a player application **238** can configure the playback device **200** to upload content to the playback server for sharing with one or more other playback devices. When content is shared with the playback device **200**, the player application **238** may configure the playback device **200** to request a top level index file from a playback server. As noted above, the request for a top level index file can include the product ID of the playback device, which can be used to filter the assets that are described in the top level index file. When the top level index file is received from the playback server, the player application **238** can configure the playback device to store the top level index file in memory **230**. In some embodiments where content is encrypted, the player application **238** may request cryptographic information to playback requested streams from the playback server (or a separate DRM server) in response to a user instruction to playback content and the cryptographic information received from the playback server can also be stored in memory **230**. The player application **238** configures the playback device **200** to playback content by requesting portions of container files containing content from a server within a content delivery network. The specific container files selected by the player application **238** can be determined based upon the information available to the player application within the top level index file and the streaming conditions experienced by the playback device. When the playback device receives the requested portions of the container files and the content is encrypted, the player application **238** can access protected content within the requested portions of the container files using the content cryptographic information. The player application **238** can continue to request and playback content from different container files depending upon the prevailing streaming conditions until a user instruction suspending playback is received or until playback completes.

Although various playback devices are described above with reference to FIG. 2, any of a variety of architectures including architectures where the player application is located on disk or some other form of storage and is loaded into memory at runtime can be utilized to implement playback devices for use in content delivery systems in accordance with some embodiments of the invention. Furthermore, any of a variety of system architectures including (but not limited) to the system architecture illustrated in FIG. 1 can be utilized to transcode content and deliver content using top level index files that are automatically generated in response to requests from playback devices in accordance with some embodiments of the invention.

#### Playback Server

In many embodiments, a user playback device may communicate with a playback server to upload content for sharing with a plurality of other devices and/or to obtain access to the content. A playback server configured to deliver content to a plurality of different devices in accordance with an embodiment of the invention is shown in FIG. 3. The playback server **300** includes a processor **310**, a network interface **340**, and a memory **330**. In the illustrated embodiment, the memory **330** includes an encoder application **332** and a content delivery application **334**. As discussed above, the playback server can be configured by the encoder application software **332** to encode and/or transcode a content file into one or more alternative streams each providing a different encoding of the content file (e.g., HEVC, H.264, among various others). In accordance with

some embodiments, the encoder application **332** communicates with one or more transcoder server clusters (not illustrated) in order to transcode a content file into the different alternative encoding streams.

The playback server can be configured by the content delivery application **334** to generate a top level index file for a playback device and/or deliver content to the playback device. In some embodiments, the top level index file is generated and/or selected based on the capabilities of the particular playback device requesting playback of content, including the video encoding/decoding capabilities of the device.

Although a specific playback server architecture is illustrated in FIG. **3**, any of a variety of architectures that are capable of managing interactions with user devices to deliver content in the manner outlined above can be utilized in accordance with some embodiments of the invention.

#### Content Transcoding and Delivery Architecture

When a user device uploads encoded content for sharing with different devices, the system may transcode the encoded content into different encoding formats in order to allow for the playback of the content on devices with different playback capabilities. An example system architecture of a content transcoding and delivery system in accordance with an embodiment of the invention is illustrated in FIG. **4**. As illustrated a client device **400** communicates through a router **401** with a server system via various server APIs **405-430** (application programming interfaces), including the user API server **405**, social API server **410**, storage API server **415**, media API server, playback API server, and transcode API server. The user API server **405** may receive user and/or device information from a client **400** and may store the information within the user database **406**. The social API server may receive social media information from the client **400** and store this information in the social database **411**. The storage API server **415** manages the storage of content stored within the content database **450**. The storage API server may receive content from the client **400**, the playback API server, and/or the transcode API server for storing in the content database **450**. The media API server **420** may communicate with player applications requesting content stored in the content database **450**. The playback API server may manage the playback of content stored within the content database **450**. The transcode API server may manage the transcoding of content, including receiving an encoded content file and transcoding it into one or more different encoding streams for storage within the content database **450**.

In order to transcode content, the transcode API server **430** may communicate with a TCE management application **435** that manages the transcoding operations taking place. The TCE management application **435** may be used for distributed coordination of the transcoding jobs, including tracking progress of a job and reporting machine load. The machine load information may be used to implement load balancing schedulers.

Each transcoding operation, illustrated as a TCE transcode node **440** may be a process that decodes and re-encodes content into one or more different encoding standards. The TCE transcode node **440** may utilize an authorization web server **445** to communicate with the storage API server for storing the alternative streams within the content database **450**.

Although a specific content delivery architecture is illustrated in FIG. **4**, any of a variety of architectures that are capable of managing interactions with client devices to

deliver content in the manner outlined above can be utilized in accordance with some embodiments of the invention.

#### Sharing and Transcoding Content

As described above, a client device may upload encoded content to a playback server for sharing with one or more other devices of the user and/or different users. A process for uploading content for sharing with different devices in accordance with an embodiment of the invention is illustrated in FIG. **5**. The process **500** receives (**505**) content for sharing with one or more devices. In some embodiments, the content is received from a playback device of a user. The content may be an encoded video file, encoded using a particular encoding standard (e.g., HEVC, H.264, among others).

The process performs (**510**) transcoding of the content into one or more different alternative encoding streams. In some embodiments, the process encodes the content into different streams based on the playback capabilities of the devices to which the content is or will be shared. For example, if a user uploads a 4K video to be shared with devices that have 4K playback and several devices that do not have 4K playback capacity (e.g., have only H.264 decoders), the process may transcode the content into both HEVC and H.264.

In accordance with some other embodiments, the process transcodes the content into a set list of alternative encodings and/or formats. For example, video content may be transcoded into several of the most prevalent encoding standards (e.g., HEVC, H.264, Microsoft™ codecs, Google™ codecs, among others) being used by devices. For example, content may be encoded using H.264/AVS to provide compatibility with the majority of devices. Thus, when a playback device requests playback of a content file, the process may provide a top level index file with a list of assets that the playback device will be capable of playing back. As described below, the top level index file may be specific to the playback device and include only those assets corresponding to encoded streams that the playback device is capable of playing back.

In accordance with some embodiments, the process begins transcoding (i.e., “pre-transcoding”) a content file into different encoding formats upon the content file being uploaded from a playback device (and prior to the different playback devices requesting the content file). In accordance with a number of certain embodiments, the process may transcode the content file into a particular encoding format upon receipt of a request for playback from a playback device. For example, the process may automatically transcode the content file into the most popular encoding formats (e.g., HEVC and H.264), but wait to transcode the content file into a less popular encoding format upon receiving a request from a playback device that requires the particular encoding format. The process may concurrently transcode and stream the content to the playback device using various “live transcoding” servers that can run several transcoding processes in parallel while serving a device’s playback requests.

The process stores (**515**) the assets. The process then completes. Although a specific process is illustrated in FIG. **5**, any of a variety of processes can be utilized for transcoding a content file in accordance with embodiments of the invention. Playback servers and processes for automatically generating index files in accordance with embodiments of the invention are described below.

#### Content Playback

A process for playing back content using a top level index file generated in response to a request from a playback

device in accordance with an embodiment of the invention is illustrated in FIG. 6. The process 600 includes requesting (605) content. The request can be performed using a playback device or can be performed using another device. In order to access the content, the playback device provides a request that prompts the generation of a top level index file customized for the specific playback device from a playback server. In accordance with several embodiments, the request takes the form of a token indicating that the playback device is authorized to request the content and the playback device provides a product identifier to the remote server via an API. In accordance with some other embodiments, any of a variety of techniques for requesting content can be utilized as appropriate to the requirements of specific applications. In accordance with many embodiments, the top level index file is customized in the sense that the playback server filters all available assets to generate a top level index file that describes the assets that are available and/or best suited to playback by the playback device. Once the custom top level index file is retrieved (610), the playback device obtains (615) cryptographic information that enables playback of protected streams identified within the top level index file. In accordance with many embodiments, playback devices wait until a playback request is received from a user and then requests cryptographic information from the playback server.

When a playback device possesses a top level index file and any necessary cryptographic information, the playback device can commence streaming and/or downloading (620) content by requesting portions of one or more container files containing encoded media. Any of a variety of processes can be utilized to select initial streams including (but not limited to) selecting the lowest bitrate streams, performing a bandwidth probe in a manner similar to the manner disclosed in U.S. Patent Publication No. 2013/0007200 to van der Schaar et al., entitled "Systems and Methods for Determining Available Bandwidth and Performing Initial Stream Selection When Commencing Streaming Using Hypertext Transfer Protocol", filed Sep. 30, 2011, or estimating available bandwidth using another technique. The disclosure of U.S. Patent Publication No. 2013/0007200 is incorporated by reference herein in its entirety.

Once playback commences (620), adaptive bitrate streaming can be performed. During playback, play event reports can be provided to a playback server to provide information concerning the playback status of the playback device periodically or in response to various events including (but not limited to) user instructions received by the playback device. When a play event report is provided to the playback server, the playback server can provide a play event instruction to the playback device. In the illustrated embodiment, the play event instructions that can be received (630) by the playback device including a "PLAY" instruction to continue playback and a "STOP" instruction to cease playback. The ability of a playback server to stop playback on a playback device enables the playback device to enforce concurrency requirements across multiple playback devices associated with a user. The combination of the play event reports and the event playback instructions can also be utilized by the playback server to enable a second playback device to resume playback of content at the last playback location reported by a first playback device. In this way, a user can seamlessly move between playback devices without the need to seek to a location to continue playback.

Although a specific process is illustrated in FIG. 6, any of a variety of processes can be utilized for requesting a customized top level index file and playing back content in

accordance with embodiments of the invention. Playback servers and processes for automatically generating index files in accordance with some embodiments of the invention are described below.

#### Automatic Generation of Top Level Indexes

Playback servers in accordance with many embodiments of the invention maintain a database of assets associated with specific pieces of content and can be configured by a playback management application to retrieve and filter information concerning assets to automatically generate a top level index file for a specific playback device. The databases maintained by the playback servers can list the name of the file containing the asset, and the content delivery servers and/or network(s) on which the asset is located. When the asset is a video stream, the database can describe characteristics of the video stream including, but not limited to, the codec of the stream, the maximum bitrate at which the video stream is encoded, the frame rate of the video stream, the resolution and/or sample aspect ratio of the video stream. When the asset is an audio stream, the database can describe characteristics of the audio stream including (but not limited to) the language of the audio stream, the encoding of the audio stream and the bandwidth requirements of the audio stream. When the asset is a subtitle stream, the database can describe characteristics of the subtitle stream including (but not limited to) the language of the subtitle stream, the encoding of the subtitle stream and the bandwidth requirements of the subtitle stream. In addition to maintaining information concerning assets, the playback device can maintain information concerning playback capabilities of playback devices. In accordance with a number of embodiments, the information concerning playback capabilities of different playback devices is indexed using a product ID. In accordance with many embodiments, the playback server also maintains information concerning rules regulating the usage of different assets based upon criteria including (but not limited to) the type of playback device, the playback capabilities of a playback device, the location of the playback device (e.g. country/region), and/or requested language (s). Although specific pieces of information are described above as being associated in a database maintained by a playback server, any of a variety of pieces of information can be maintained in any of a variety of data structures to enable generation of a top level index file by a playback server in accordance with some embodiments of the invention. Furthermore, a playback device can provide a listing of its capabilities directly to the playback server. As is discussed further below, the information maintained by the playback server can be filtered in real time in response to a request for a top level index file from a playback device to generate a top level index file that only includes links to the assets that the playback device is permitted to playback.

A process for generating a top level index file using information concerning assets associated with specific pieces of content maintained by a playback server in accordance with an embodiment of the invention is illustrated in FIG. 7. In the illustrated embodiment, the process 700 commences when the playback server receives (705) a request for a top level index file with respect to a specific piece of content from a specific playback device. As discussed above, the request can include information describing the playback device including (but not limited to) the playback capabilities of the playback device, a user account to which the playback device is registered, and information indicative of the geographic location of the playback device (e.g. the I.P. address of the playback device). In accordance with many embodiments, the capabilities of the playback



device are identified using a product ID, which is associated with specific playback capabilities in a database accessible to the playback server.

The playback server retrieves (710) assets associated with the requested piece of content. The playback server filters (715) the assets based upon one or more filters associated with the capabilities of the playback device, the preferences of the user, and the requirements of the content owner. Accordingly, different top level index files can be generated with respect to the same content dependent on factors including (but not limited to) differences in playback capabilities (e.g., codec, resolution, memory) between devices, differences in geographic location, and/or differences in language preferences associated with the playback devices. For example, if a user uploads a 4K video for sharing, the top level index file for a device capable of playing the 4K video may include the 4K stream while the top level index file for a device that is not capable of playing the 4K video may not include the 4K stream, but rather a stream (e.g., H.264) that the device is capable of playing back.

Following filtering, the remaining assets can be utilized to generate (720) the top level index file, which can be provided (725) to the playback device. In accordance with a number of embodiments, the top level index file is securely forwarded using a secure communication technique including, but not limited to, Secure Socket Layer (SSL) communication or an equivalent secure communication protocol.

Although a specific process for generating a top level index file in accordance with an embodiment of the invention is illustrated in FIG. 7, any of a variety of processes involving collecting information concerning assets associated with a specific piece of content and generating an index file that indexes the assets that are to be made available to a playback device by a content delivery streaming system can be utilized in accordance with some embodiments of the invention. A communication diagram illustrating the series of communications between playback devices and servers in order to share content in accordance with embodiments of the invention are discussed below.

#### Communication Between Devices and Servers

Many embodiments of the invention provide for uploading content from user devices for sharing with other devices, transcoding the content into one or more different encoding formats, and generating top level index files of the different encoding formats based on the capabilities of the different devices. In order to facilitate the sharing of the content, the client devices communicate with various different server systems to upload content, transcode content, and/or receive top level index files. An example of communication between client devices and/or the various different server systems in accordance with an embodiment of the invention is illustrated in FIG. 8.

FIG. 8 illustrates the communication between playback devices A 805 and B 810, a playback server 815, a transcoding server cluster 820, and a content delivery server 825. The playback devices 805-810 and different servers 815-825 may communicate with each other over a network such as the Internet. As described above, the playback server 815 may provide an interface accessible to the client devices 805-810 for uploading content (e.g., video files, photos, and/or audio files, among others) via an application on their client devices 805-810. The playback server 815 can be used to receive a content for sharing with one or more devices 805-810, to transcode the content into one or more different encoding formats, to generate top level index files for playback devices, and to deliver content to the playback devices. The playback server 815 may also provide crypto-

graphic information used to access digital content that has been encrypted (e.g., using a DRM server).

The playback server 815 may use one or more transcoding server clusters 820 in order to transcode a content file into one or more different encoding formats and/or store the content within a content server 825.

The content server 825 may provide the content to a client device 805-810 requesting playback of a piece of content. The content can be downloaded and/or streamed by a client device 805-810.

The communications illustrated in FIG. 8 for uploading content from a client device for sharing with one or more other devices may proceed according to the following series of communications. The client device 805 uploads content for sharing to the playback server 815. The content may be a video file encoded according to a particular standard (e.g., H.264 or HEVC for 4K video). Where the playback device has transcoding capabilities, the playback device may also perform transcoding of the video file prior to uploading.

The playback server 815 requests transcoding of the content to the transcoding server cluster 820.

The transcoding server cluster 820 transcodes the content into one or more different alternate encoding streams. The transcoding server cluster 820 stores the alternative encoding streams with the content server 825 and provides a list of the alternative streams to the playback server 815.

A different playback device B 810 may request playback of the content file, and submit a request for a top level index file to the playback server 815 using any of the techniques described above. The playback server 815 may generate a top level index file. In some embodiments, the top level index file is generated based on the playback capabilities of the playback device. In other embodiments, the playback server may select a top level index file from a plurality of index files based on the product ID of the playback device.

The playback server 815 provides the playback device B 810 with the top level index file.

The playback device B 810 may provide a play request to the playback server 815. The playback server 815 provides cryptographic information to the playback device B 810 for decrypting the encoded content.

The playback device B 810 uses the top level index file to request content from the content server 825. The content server 825 provides the content to the playback device 810. The playback device decrypts the content using the cryptographic information in order to playback the content on the device.

Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of the invention. Various other embodiments are possible within its scope. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their equivalents.

What is claimed is:

1. A content server that provides encoded media to playback devices comprising:
  - a processor;
  - a memory readable by the processor; and
  - instructions in the memory that when read by the processor direct the processor to:
    - receive shared media content from a first playback device;
    - request transcoding of the shared media content into a plurality of assets from a transcoding server, wherein

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the plurality of assets can be used to provide the shared media content in a plurality of alternative streams;

obtain a list of the plurality of assets that includes information that can be used to filter the assets within the list;

receive a request for the shared media content from a second playback device where the request includes device capability information of the second playback device;

generate a top level index file that includes information for assets that can be used to provide the shared media content to the second playback device by filtering the list based upon the device capability information for the second playback device; and

transmit the top level index file to the second playback device.

2. The content server of claim 1 wherein the device capability information provided by the second playback device includes a product identifier for the second playback device and the instructions further direct the processor to:

determine the capabilities of the second playback device from the device capability information in the request by retrieving the capabilities of the second playback device from a memory that stores the capabilities of a playback device having the product identifier of the second playback device included in the device capability information.

3. The content server of claim 1 wherein the capabilities of the second playback device are included in the device capability information in the request and the instructions further direct the processor to determine the capabilities of the second playback device from the device capability information in the request by obtaining the capabilities of the second playback device from the device capabilities information in the request.

4. The content server of claim 1 wherein the assets included in the top level index file are also based upon rules regulating the use of different assets for providing the media content that are stored in memory.

5. The content server of claim 4 wherein the rules regulating the use of different assets include at least one rule selected from the rules consisting of: the type of playback device, the playback capabilities of the device, location of the device, and a requested language.

6. The content server of claim 1 wherein the assets included in the top level index file are also based upon at least one criteria selected from the group of criteria selected from the group consisting of user preferences, and requirements of the content owner.

7. The content server of claim 1 wherein the request includes a token that the second playback device received from the first playback device and the instructions further direct the processor authenticate the token and provide access to the shared video content in response to the authentication of the token.

8. The content server of claim 7 wherein the instructions to provide access to the shared video content include instructions to direct the processor to provide decryption information for the shared media content to second playback device.

9. The content server of claim 1 wherein the instructions further direct the processor to receive a play request for an asset in the top level index from the second playback device.

10. The content server of claim 9 wherein the instructions further direct the processor to provide cryptographic information for decrypting the asset to the second playback device in response to the play request.

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11. A method for providing a top level index file to a playback device that includes information for assets that may be used to obtain media content comprising:

receiving shared media content from a first playback device in a content server;

requesting transcoding of the shared media content into a plurality of assets from a transcoding server, wherein the plurality of assets can be used to provide the shared media content in a plurality of alternative streams by the content server;

obtaining a list of the plurality of assets that includes information that can be used to filter the assets within the list by the content server;

receiving a request for the shared media content from a second playback device in the content server where the request includes device capability information of the second playback device;

generating a top level index file using the content server that includes information for assets that can be used to provide the particular media content to the second playback device by filtering the list based upon the device capability information for the second playback device; and

transmitting the top level index file from the content server to the second playback device.

12. The method of claim 11 wherein the device capability information provided by the second playback device includes a product identifier for the second playback device and the method further comprises:

determining the capabilities of the second playback device from the device capability information in the request by retrieving the capabilities of the second playback device from a memory that stores the capabilities of a playback device having the product identifier of the second playback device included in the device capability information using the content server.

13. The method of claim 11 wherein the capabilities of the playback second device are included in the device capability information in the request and the method further comprises:

determining the capabilities of the second playback device from the device capability information in the request by obtaining the capabilities from the device capabilities information in the request using the content server.

14. The method of claim 11 wherein the assets included in the top level index file are also based upon rules regulating the use of different assets for providing the shared media content that are stored in memory.

15. The method of claim 14 wherein the rules regulating the use different assets include at least one rule selected from the rules consisting of: the type of playback device, the playback capabilities of the device, and location of the device, and a requested language.

16. The method of claim 11 wherein the assets included in the top level index file are also based upon at least one criteria selected from the group of criteria selected from the group consisting of user preferences, and requirements of the content owner.

17. The method of claim 11 further comprising receiving a play request for an asset in the top level index from the second playback device.

18. The method of claim 17 further comprising providing cryptographic information for decrypting the asset to the second playback device in response to the play request.

19. A non-transitory machine readable medium containing processor instructions, where execution of the instructions by a processor causes the processor to perform a process to

provide a top level index file including information about assets to use to obtain a particular media content comprising:

- receiving shared media content from a first playback device;
- requesting transcoding of the shared media content into a plurality of assets from a transcoding server, wherein the plurality of assets can be used to provide the shared media content in a plurality of alternative streams;
- obtaining a list of the plurality of assets that includes information that can be used to filter the assets within the list;
- receiving a request for the shared media content from a second playback device where the request includes device capability information of the second playback device;
- generating a top level index file that includes information for assets that can be used to provide the particular media content to the second playback device by filtering the list based upon the device capability information for the second playback device; and
- transmitting the top level index file to the second playback device.

**20.** The non-transitory machine readable medium of claim **19**, wherein the instructions further comprise:

- receiving a play request for an asset in the top level index from the second playback device; and
- providing cryptographic information for decrypting the asset to the second playback device in response to the play request.

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